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Potentially habitable ancient environments in Gusev crater, Mars

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Habitable environments must sustain liquid water at least intermittently and also provide both chemical building blocks and useful sources of energy for life. Observations by Spirit rover indicate that conditions have probably been too dry to sustain life, at least since the emplacement of the extensive basalts that underlie the plains around the Columbia Memorial Station landing site. Local evidence of relatively minor aqueous alteration [1] probably occurred under conditions where the activity of water was too low to sustain biological processes as we know them.

In contrast, multiple bedrock units in West Spur and Husband Hill in the Columbia Hills have been extensively altered. Patterns of elemental abundances are consistent with aqueous processes involving migrating fluids [2]. Fe in several of these units has been extensively oxidized [3]. Conceivably any microbiota present during the aqueous alteration of these rocks might have obtained energy from Fe oxidation. Spirit discovered olivine-rich ultramafic rocks during her descent from Husband Hill southward into Inner Basin. Alteration of similar ultramafic rocks on Earth can yield H_2 that can provide both energy and reducing power for microorganisms.

Spirit's discovery of deposits rich in ferric sulfate is consistent with the aqueous dissolution and/or alteration of olivine under acidic conditions [2] such as those associated with hydrothermal activity. The oxidation of iron and sulfur that can accompany such activity can be an energy source for life. Hydrothermal systems on Earth that sustain either acidic [4] or neutral to alkaline fluids [5] have been shown to provide this energy. Collectively the observations by Spirit rover are consistent with the possibility that habitable environments existed in Gusev crater at least intermittently in the distant geologic past.

[1] Haskin et al. (2005) Nature **436**, 66-69. [2] Ming et al. (2008) JGR **113**, E12S39, doi:10.1029/2008JE003195. [3] Morris et al. (2008) JGR **113**, E12S42, doi:10.1029/2008JE003201. [4] Innskeep & McDermott (2005) In: Geothermal Biology & Geochemistry in Yellowstone N. P., Montana State Univ., 143-162. [5] Shock et al. (2005) In: Geothermal Biology & Geochemistry in Yellowstone N. P., Montana State Univ., 96-109.